SOAPBOX DIGEST

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Grid Computing in K-12 Schools

An e-mail-based Soapbox discussion by IAETE

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>
> —*Dr. Wolfgang Gentzsch*

Modeling and visualization have emerged as essential tools for scientists who have access to supercomputers. Models are complex simulations. Visualizations are displays that reveal hidden correlations. Both rely on large, stable databases in areas such as atmospheric sciences, ecology, biology, and sociology.

Grid computing holds the promise that every K-12 school could have supercomputing capabilities within a few years, and thus access to these real-world database, modeling, and visualization tools. Grid computing allows large groups of computers (either in a lab, or remote and connected only by the Internet) to extend extra processing power to each individual computer to work on components of a complex request. Grid middleware, recognizing priorities set by systems administrators, allows the grid to identify and use this power without interfering with what the desktop or laptop user is doing.

An August 2004 Soapbox panel examined what this emerging technology might bring to schools. Panelists were

- **Michael A. DeMiranda,** Ph.D., Associate Professor, Technology Education and Training, School of Education, Colorado State University, and Cochair, Education Advisory Committee for the Colorado Grid Computing Initiative (http://istec.colostate.edu/cogrid.htm)
- **Edna E. Gentry,** Senior Research Information Scientist, University of Alabama, Huntsville. Edna works with ASPIRE (http://aspire.cs.uah.edu/), the Alabama Supercomputing Program to Inspire computational Research in Education.
- **Wolfgang Gentzsch,** Managing Director of MCNC Grid Computing & Networking Services (http://www.mcnc.org/)
- **Scott Lathrop,** Associate Director for Education, Outreach, and Training, National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, www.ncsa.uiuc.edu

Though grid technology is in the early stages of development, past supercomputing projects for K-12 schools give a clear picture of what

success can look like. Gentry and Lathrop bring extensive experience with K-12 supercomputing projects and competitions to the discussion. DeMiranda is planning the K-12 educational components of COGrid, a state grid to be built in Colorado. Gentzsch, who led global grid technology development at Sun Microsystems before joining MCNC, brings 25 years of grid technology expertise to the group.

The discussion focused on the benefits of fostering inquiry-based science and new possibilities for assessment and data-based decision making. Additional benefits abound, including advanced communications, collaboration opportunities, building interest in computational science, and giving students experience with what will become more common tools in society.

So compelling are the benefits, all felt a need to actively promote grid computing. Writes Lathrop,

> "As the data revolution directly parallels the advances in modeling and visualization, it is incumbent on us to prepare the next generation to be able to collect, manage, analyze, and disseminate the information for future generations."

Previous work in K-12 supercomputing provides pockets of experience in what grid computing can bring to schools, but scaling this beyond elite projects will require effort. The panel suggested a meta-analysis of studies from K-12 supercomputing; professional development (particularly at the preservice level); a Web-based clearinghouse of models, visualizations, and databases available to K-12 schools; and other first steps in helping schools benefit from the roll-out of this promising technology. The group also provided information for administrators on a school or district's potential economic position in a larger grid.

Promoting Inquiry-Based Science Education

> "Many teachers have become motivated by their summer workshop experiences and have vowed never to go back to traditional teaching methods. These teachers are motivating their students to engage in compelling problem solving, to ask and answer questions that would not ordinarily come up in their classroom discussions. These are teachers who are not afraid of not knowing the answer and are ready to take a risk."
>
> —*Edna Gentry*

Gentry, in the quote above, describes a significant change from the norm in science classes, a norm DeMiranda defines in his opening comment:

> I wish to preface my remarks by first reminding our audience that recent studies in science and mathematics suggest that most K-12 students perceive learning in science and mathematics as a passive process of observing, recording, or otherwise performing rote skills with little in-depth cognitive engagement in performing scientific inquiry, forming questions, and seeking novel approaches to coming to know.

The participants were willing to give their time to the discussion because the idea of grid computing, modeling, and visualization in K-12 schools is not only exciting but also a realistic possibility. In defining the various types of models and simulations, DeMiranda writes, "Advanced computing and visualization tools in K-12 classrooms have the potential to move scientific and mathematical education into the powerful realm of explanatory, synthetic modeling." These people have seen students work with real tools to turn science from a passive experience to an inquiry-based pursuit. They have seen teachers dramatically change pedagogy.

The group cited many workshops and projects that foster this type of pedagogical change, along with impressive tales of student work. Two high school brothers, for example, developed a model on the propagation of the West Nile Virus using an icon-based modeling tool known as STELLA. This was possible because their teacher had learned about the technology in a training program in computational science as a result of having won a grant from the National Computation Science Leadership Program (NCSLP, at http://www.ncsec.org). Lathrop runs many such projects through NCSA. Gentry, in fact, was introduced to supercomputing in 1991 through training at the Alabama Precollege Supercomputing Teacher Training and participation in SuperQuest at the University of Illinois.

Schools have had access to supercomputers and simulations that run on them through federally funded labs such as NCSA, The Department of Energy, and NASA. Communications with supercomputers are available via the Web, and many models that once required supercomputing can now run on desktop PCs. As these technologies grow, NCSA strives to provide "authentic scientific learning opportunities" in which students "use the same tools, data, and resources used by scientists," says Lathrop. He points to tools such as the Biology Workbench (http://workbench.sdsc.edu), which provides a common interface to more than 80

protein and genomic sequence databases through a Web interface, and which is frequently used by scientists. NSF funding created the Biology Student Workbench (http://peptide.ncsa.uiuc.edu), a student version that scaffolds the sophisticated interface and provides tutorials. Lathrop also pointed to Chickscope (http://chickscope.beckman.uiuc.edu/) and Bugscope (http://bugscope.beckman.uiuc.edu/), two projects that introduce the use of scientific instruments (MRI and electron microscopes) to K-12 classrooms. Writes Lathrop,

> "Through the use of grid computing, students are able to remotely access these devices. This creates enthusiasm among students as they use the same tools used by scientists, with scaffolding to make them appropriate for these age levels. Lesson plans and teacher guides have been developed that have allowed numerous teachers to independently learn and apply these tools in their own classrooms. Similar capabilities provide students access to other unique devices (such as telescopes and earthquake engineering devices) used by scientists that are too expensive to provide in classrooms."

Several panelists expressed that the scientists who develop these tools are open to creating K-12 interfaces for their complex tools.

Assessment and Data-Based Decision Making, an Administrative Benefit

> If we are to really push the envelope of grid computing power we should be discussing how supercomputing can be used to monitor, track, and model individual student cognitive growth and development across knowledge domains.
>
> —*Michael DeMiranda*

Data mining, in which patterns of student and school performance can be determined based on multiple data sets over time, is potentially a key application for school grids. Actual assessments could change with access to grid computing, but so could the way the data from results is used. For this very specific interest, the moderator asked John Lee of CRESST (National Center for Research on Evaluation, Standards, and Student Testing) about the assessment benefits he saw with grid computing. Lee pointed to the potential to work with much larger databases, which could create the possibility of state data systems going down to the classroom level. He also saw possibilities for analysis of student work (digital portfolio items) with systems such as automated essay scoring, which require high amounts of computing power. (Gauging expertise with students' concept maps is another potential assessment that would require significant computing power. See IAETE's assessment symposia for a summary of this work, much of it from CRESST.)

"Today's data-mining tools, coupled with high-performance computing systems, create the potential to revolutionize the assessment process," says Lathrop. He is currently working with assessment experts to develop prototypes that show "The potential of these tools in education." In this discussion, Lathrop provides an overview of the data-gathering and analysis tools being developed for science and engineering. He observes that "Taken one step further, we believe these new data-mining algorithms and tools can also offer tremendous benefit for student assessment at the national level, state level, district level, and even in the classroom." He points to student artifacts (such as essays and homework assignments) in digital form, time-on-task measurements with sensors, communications between students and teachers, school and community information, and national and state learning goals as some of the data that could feed such a system.

This deluge of data also leads Lathrop to observe that "privacy issues are a significant challenge in collecting and analyzing this information. Collectively, educators, administrators, researchers, and policymakers need to work together to identify methods for conducting in-depth analyses that will benefit the individual (and, in the process, the whole school system) while protecting the rights of the individuals."

The Challenge of Adoption

> What does it take to get broad acceptance? Who needs to be convinced? What do they need to be convinced?
>
> —*Scott Lathrop*

The promise of assessment is modeled on data-mining success with supercomputing in other industries. The promise of inquiry-based science comes from previous supercomputing projects. In both cases, the grid's role in K-12 schools brings up the question of scale. Lathrop writes,

> The hard question, from my perspective, is how to get buy-in for the integration of modeling and visualization across multiple subject areas as a continuum across multiple grade levels (K-12, higher ed). We see pockets of exemplary teaching and learning, and more of them every

> year. But we don't see systemwide acceptance of modeling and visualization as essential elements in the learning standards and thus in all classrooms. We also see gaps in the continuum where some kids get excited and engaged only to get turned off at the next level, such as not finding similar engaging learning paradigms when they move from middle school to high school, or when they move from high school to college.

Few schools cry out that they are starved for computer cycles. Indeed, Dr. Miranda suggests the real question is, if we build it, will they come? A first step, agreed the group, would be to build awareness of what is possible and then provide professional development. Gentry speaks from experience when she observes that

> most teachers are not going to become knowledgeable about the availability of models, curriculum materials, and computing capabilities on their own. They need someone to introduce them [to such resources], to support them during their learning time, and then give them the environment where they can explore their capabilities. For them this does not happen during one summer workshop. Sometimes it takes years to gain proficiency with tools and techniques.

Lathrop writes,

> I second Edna's comments wholeheartedly. We often find that awareness is the biggest problem. Educators (K-12 teachers, faculty, etc.) just aren't aware of the tools and resources available to them (many freely available on the Web) that can garner this excitement and engagement by their students while also addressing the learning standards. Educators need more professional development opportunities to open their eyes to these opportunities, and then the time to learn, practice, apply, evaluate, and repeat the cycle.

The education and outreach projects of NCSA, explains Lathrop, guide "educators through three phases of applying modeling and visualization in their classrooms. First is introducing educators to OPM (other people's models) and OPV (other people's visualizations). Next is supporting educators in understanding how to modify these models/simulations. Assisting educators in developing new models/simulations is the final phase."

Confidence in the Technology

> "Is grid technology ready for K-12 schools? I must say, 'No, not yet!'"
>
> —*Wolfgang Gentzsch*

Confidence in the technology is also essential to speeding the adoption rate. Apart from the technology-use issues specific to schools, panelists pointed to common traits of technology resistance and adoption. Lathrop pointed to the insightful book *Crossing the Chasm,* a highly respected guide for marketing emerging technologies, by Geoffrey A. Moore.

Similarly, Gentzsch clipped in his article titled *The Three Waves of the Grid Computing Evolution*. Given the three waves of research, business, and consumer, Gentzsch says we are beginning the second wave. Further, each wave requires distinct actions for different needs. Writes Gentzsch,

> According to this wave model, we at MCNC have developed our own roadmap to help introduce grid computing in education, research, industry, and economy in North Carolina. We see our activities evolving in three phases: Phase 1 is "awareness creation," Phase 2 is "easy access," and Phase 3 is "providing grid services" in a professional way. I believe K-12 education can't really be faster than the researchers at universities in creating the awareness of this new technology and its benefits. And researchers today are still struggling with immature grid technology (including missing standards) and the wider acceptance of it. We are still in the "awareness creation" mode, far away from "easy access" as we are used to with Internet-based e-learning tools today. It might still take 2 to 3 years to see some good grid portal technology enabling our kids easy access to this wealth of resources and knowledge.

Security, in Lathrop's words, is also "a significant challenge in grid computing." However, panelists seemed confident that security needs would be met by the time grid computing reaches the schools. Bandwidth is also a concern. Writes Lathrop, "The other potentially limiting factor for schools will be their network bandwidth to the outside world. The more simultaneous use of the external link, the greater the bandwidth needed to support the transfer of information."

Schools in the Grid Economy: The Business Model

A grid could be of about any size. Laptops in a single classroom could make a grid, as could a computer lab. Organizations across the globe could be linked into a grid. A grid could be made of many smaller grids. Gentzsch thinks most K-12 grids will begin within the building or district, primarily because of security issues. Schools would then have the option of tying into a larger grid outside of the school system, and

this would carry benefits and risks. Given a fictional superintendent who suspects the grid is just after her district's processing power, Gentzsch lays out the technical abilities of grids as well as the human motivations for sharing or selling.

Advantages, he explains, include the ability to occasionally use more processing power than the school has on its own. Involvement might also bring technical expertise or university science mentors. Adds Gentry, "It becomes clear that under the right circumstances, schools are willing to share their resources if they are able to gain a benefit for their students. Benefits might include videoconferencing capabilities, high-speed network connectivity, and after-hours access by students and teachers/school personnel."

The school most certainly has something to offer the grid, vastly underused processing power. Gentzsch estimates that, like our brains, less than 10 percent of the processing power of a computer is used.

IAETE thanks these exceptional contributors as work begins to help schools prepare for the deal-making, set-up, and beneficial use of grid computing.

More From the Transcript

- What is a grid?
- To learn more about grid computing
- Comparing grid technology to a human grid
- Paying for grid use (one idea)
- Schools in the grid economy: The business model
- Barriers to adoption of grid technologies, and strategies to overcome them
- Modeling and visualization tools
- Grid computing organizations
- Grid technologies software
- Benefits of grid technologies for schools

Modeling and Visualization Tools

- The Biology Student Workbench (http://peptide.ncsa.uiuc.edu/)
- Chickscope (http://chickscope.beckman.uiuc.edu/)
- Bugscope (http://bugscope.beckman.uiuc.edu/)
- Chem Viz (http://chemviz.ncsa.uiuc.edu/). A modeling/vis tool for learning chemistry, Chem Viz runs computations on remote supercomputers and returns a visualization that is viewed on the student's computer.
- National Science Digital Library (http://www.nsdl.org/)

Grid Computing Organizations

- The Education, Outreach and Training program, supported by NSF (http://www.eot.org)
- The NSF-funded REVITALISE (http://revitalise.ncsa.uiuc.edu/)
- The National Computational Science Institute (http://www.computationalscience.org) introduces modeling and visualization to K-20 educators.
- The Shodor Education Foundation, Inc., a national research foundation for computational science education, (http://www.shodor.org) publishes models/simulations and the curricular materials used and created by National Computational Science Institute participants.
- National Computation Science Leadership Program (NCSLP) (http://www.ncsec.org)
- The Siemens-Westinghouse competition (http://www.siemens-foundation.org/
- High schools students are using the same online WebCT training courses as the research community to learn how to program applications for high-performance computing systems like MPI (message passing interface) (http://www.ncsa.uiuc.edu/Divisions/eot/Training/WebCT/).
- Educators and students are now able to participate in remote workshops and training sessions using Access Grid technologies (http://www.accessgrid.org/).

This document summarizes an e-mail-based panel discussion that took place in 2004. It is part of the continuing Soapbox online forum sponsored by the Institute for the Advancement of Emerging Technologies in Education (IAETE) at AEL. The mission of the Soapbox forums is to sponsor discussion among educators, education researchers, technology industry leaders, and others interested in technology's role in advancing education. To find complete quotes in context, the discussion is posted on the Web at www.iaete.org/soapbox.

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